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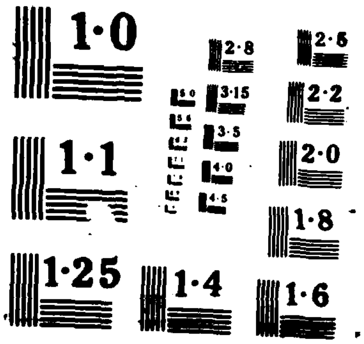
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COEDS Workstation Selection Recommendation

Telecommunications and
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This report proposes a set of requirements for the communications engineering design system (COEDS) to be used for the evaluation of contending equipment. These requirements encompass a wide range of considerations to ensure a useful and cost effective recommendation throughout the lifecycle of the COEDS project. Characteristics of currently available systems are evaluated and a recommendation is made for the COEDS design station.

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Table of Contents

1.0 INTRODUCTION

The goal of the COEDS program is to place an integrated set of software tools in the hands of an experienced engineer to increase his effectiveness in completing shipboard RF communication systems design. These tools are to be available to the engineer on a personal workstation. Providing the engineer with extensive computational resources for his/her exclusive use is perceived to be a crucial element in the effectiveness of the COEDS project. These local resources will provide three major advantages for the user:

1. Decrease the system response time. The designer's time should not be wasted by waiting for access to a shared computer resource (such as a batch computing environment), or in waiting for responses (such as in a time-shared environment).

2. Improve the user-program interaction. Software systems can interact with the user in a much more useful and responsive manner when the computational resources are local and dedicated to the user.

3. Provide graphic displays of input and output information that are not feasible in batch or time-shared environments.

In this report, we first propose a set of requirements for the COEDS engineering design system to be used for the evaluation of contending equipment. These requirements do not focus on raw computational capabilities, but encompass a wider range of considerations to ensure a useful and cost effective recommendation throughout the lifecycle of the COEDS project. The requirements are grouped into six major categories which will be addressed individually.

1. Cost Effectiveness
2. Compatibility with Existing Computing Facilities
3. Hardware Capabilities
4. Software Support
5. Network Integration
6. Vendor Support

After presenting a full description of the requirements, produces currently available on the market are reviewed relative to the desired capabilities. For this review, a large number of single-user computers are divided into five major classes:

1. Equipment from major computer companies
2. "AI" workstations
3. Workstations from established companies
4. Workstations from emerging companies
5. Microcomputers

Our recommendation for the COEDS design station is presented in the final section.

2.0 COEDS DESIGN SYSTEM REQUIREMENTS

2.1 Cost Effectiveness of the Complete System

In the evaluation of computer equipment it is important to look beyond the price of original hardware configuration. Generally, the cost of additional peripherals, software and maintenance significantly exceed the purchase price of the hardware. It is critical to compare the costs of COMPLETE systems, which includes all required peripherals, software packages, and integration into the NOSC network environment.

To offer NOSC the greatest flexibility in later stages of implementing the COEDS project, it is desirable to choose a product line with a range of models in various price ranges. A wide range of models will allow various configurations to be implemented with possible cost savings by configuring equipment to meet each user's specific requirements. If the vendor has a long term commitment to the chosen product line, then NOSC may take advantage of further cost reductions when the vendor introduces newer versions of equipment (assuming prices continue to drop).

It is desirable for the system chosen to be able to perform a variety of computational functions and thereby offer greater user services for the same (or even slighter higher) price.

Finally, the availability and cost of hardware and software maintenance must be considered in the evaluation of systems.

2.2 Compatibility With Existing Computing Facilities

In order to protect NOSC's large investment in software, the chosen system should be compatible with existing software. This will also reduce the overall cost of development of COEDS if existing codes can be incorporated into COEDS.

In addition, compatibility with existing operating systems and user interfaces will make the COEDS system more convenient to use.

2.3 General Requirements for the Design System Hardware

The idea of personal workstations is just emerging in the computing industry as a result of continued dramatic advances in computer hardware and software. However there is still not a well-accepted definition of "personal workstation". At the First International Conference on Workstations in San Jose, California in November 1985, a significant amount of discussion concerned the definition of a "workstation". The attendees could only generally agree that what constitutes an effective workstation depends on the particular application.

To meet the requirements of the COEDS project, the workstation must be considerably more powerful than many of the current industry offerings.

1. The design problem for COEDS, shipboard RF communications, is a computationally difficult problem. Due to the number of free variables, many calculations are required.

2. Large amounts of output data will be generated and must be displayed in a useable format.

3. Relatively large data bases (such as Navy equipment inventories) will be accessed.

4. The long-range goals of COEDS include developing an "intelligent system" to assume many of the engineer responsibilities.

The following sections identify the major components of a personal workstation, and describe the desired characteristics for each of these components individually.

2.3.1 Central Processing Unit (CPU)

The computational rate of the CPU alone is not a good measure of the overall system performance. Therefore, no CPU specifications in terms of cycles per second will be established. However, other features of the CPU, which relate to system performance, can be specified. They are:

1. 32-bit address and data paths. The large address space provided by 32-bit address lines permits clearer and more robust software development, and is especially important for "intelligent system" applications. 32-bit arithmetic processing greatly improves the system performance in computational tasks.

2. Memory Management Unit (MMU). An integral hardware unit to map virtual (32-bit) addresses to physical memory locations is required to ensure that the CPU will not require wait states for memory access. A high speed cache is another desirable feature to help match CPU and memory speeds.

3. Floating Point Hardware. Many of the calculations required in the software components of COEDS operate on real or floating point numbers. Hardware floating point units typically offer ten to twenty times the performance improvement over these operations performed in the CPU.

Many of the major semiconductor companies offer chip sets that provide these features. These include the Motorola 68020, National 32032, and Intel 80286 and 80386. These chip sets, or occasionally a proprietary design (such as the microVAX chip set), are included in most of the high performance workstations being sold today. Raw computational power seems to be the simplest requirement to meet. It is critical, however, that the remaining components of the system which are described in the following sections match the performance of the CPU so that the CPU can be effectively utilized.

2.3.2 Disk Storage

A hard disk with a capacity greater than 50 Mbytes is desirable for storing equipment data bases, large volumes of output, and large virtual spaces for program images. Disk performance, with access times less than 40 msec, is important to minimize the I/O bottleneck and transfer rates exceeding 5 Mbps.

A backup system is required in conjunction with the disk. The most suitable and cost effective is the quarter inch tape cartridge.

2.3.3 Bit Mapped Display

A high resolution (approximately 1024 bit x 1024 bit) bit-mapped display on a large format (19 inch or larger) screen is required for the level of user interaction proposed in COEDS. A display device with these characteristics allows the presentation of graphic representation of complex objects such as the topside of a ship. With a large format display several related pieces of data can also be presented simultaneously.

A color display is a desirable feature. Color adds an additional dimension to the display of complex objects, such as a three-dimensional presentation of an antenna pattern. Color is also very effective for emphasizing a specific portion of a complex output and for distinguishing closely related data.

Support of a high resolution color display, however, requires significantly greater computational power and I/O bandwidths. Workstations that support these demands are just now appearing in the marketplace.

2.3.4 User Input Devices

Some form of pointing device is necessary for improving user interaction, especially in activities that involve graphic representation of objects. The keyboard is particularly unsuited for describing graphic objects. The two leading input alternatives are a digitizing tablet and a multi-button mouse. Although, the digitizing tablet permits more precise user input, it is also less flexible to use due to the physical constraints of the tablet.

2.3.5 Hardcopy Output Device

Printer technologies have not generally kept pace with high resolution CRT displays. The most effective method to obtain a paper copy of the information displayed on the bit-mapped display, is with a laser printer. Laser printers, however, do not produce color output.

Perhaps the best solution is to provide a high quality hardcopy device on the network.

2.4 General Requirements for the Design System Software

Traditional software packages (e.g., editors and debuggers), including the basic operating system, were not designed for the workstation hardware environment described in the previous sections. In previous applications both machine power and I/O bandwidths were severely limited, and software typically went to great lengths to conserve these scarce resources. However, the computational power, I/O bandwidth, and display resolution provided by current workstations, allow a radical departure from the software systems developed in more limited hardware environments.

One example of this change in the software system environment is the multiple window user interface originally developed by XEROX. This capability allows the user to simultaneously view results from a number of different activities, and to quickly switch back and forth among these activities.

Development of an integrated tool set to provide a more general and flexible user interface is a very large task and is dependent on the particular hardware capabilities provided by a workstation. Therefore, it is important that the workstation operate in an integrated hardware AND software environment. The vendor must supply convenient access to interaction facilities via a set of standard program libraries that are accessible from high level languages.

2.4.1 Support for Multiple Windows

The ability to simultaneously display several different results (or the same results in a variety of formats) will greatly increase the effectiveness of the COEDS user.

Although many vendors support a window environment, applications programs are not always accessible via the window control mechanisms. For development of COEDS, the workstation must supply standard subroutine calls that allow a user written program to create, delete and otherwise modify windows on the display screen.

2.4.2 Programming Environment

Since the software development for COEDS will be done on the workstation delivered to NOSC, it is important that a rich programming environment be provided with this workstation. This environment must include more than the standard set of program editors, compilers and linkers provided on mainframe computers.

Additional tools that are necessary are: high-level language symbolic debuggers, language sensitive editors, and code management systems. To be most effective, these tools should take advantage of multiple screen windows and high resolution graphics supported by the hardware.

2.4.3 Additional Packages for Integration into COEDS

In order to minimize the cost and time of development for the COEDS project we will attempt to use existing software where ever possible. This will include programs previously developed at NOSC and third party software for tasks such as database management. Therefore, it is desirable to choose a system which supports a variety of other software developments.

2.5 Network Integration

Although the majority of the processing required by the COEDS user will be performed locally, it important that the user NOT be isolated from other computing facilities and users with access to other computer facilities. A local area network interface is an integral portion of the COEDS workstation.

The network should provide the COEDS user access to large computer facilities (used for electromagnetic calculations), access to large centrally maintained databases, and communication links to other users on different COEDS workstations and users on other projects.

Network integration must also include the software support for higher level protocols.

The details of the network interface will be dictated by the network planning at NOSC.

2.6 Vendor Support

The quality of vendor support will have a dominant effect on the long term costs of the hardware configuration chosen. The viability of the vendor and their long term commitment to the chosen product line are important considerations for the continued operation of the COEDS program (without incurring the high cost of converting the system to run in a different environment).

The level of maintenance and response time for repairs is a significant concern for the availability of the system.

Expectations for product line growth and development should be considered for planning follow on work in the COEDS program.

3.0 EVALUATION OF CURRENTLY AVAILABLE SYSTEMS

The market for single-user computer systems is extremely volatile at the current time. There are new companies and new models from existing companies appearing (or promised) almost daily. To evaluate these systems for use in the COEDS project, we have divided the market into five significant groups:

1. Equipment from major computer companies
2. "AI" workstations
3. Workstations from established companies
4. Workstations from emerging companies
5. Microcomputers

We have compared the general characteristics of machines in each class to the requirements previously established for COEDS.

3.1 Equipment from Major Computer Companies

The majority of the established computer vendors, including DEC (Digital Equipment Corporation), HP (Hewlett-Packard), Honeywell, and Data General, have developed computer systems that fall into the category of single-user workstations. The largest computer supplier, IBM, has not yet announced a workstation product, but there are numerous rumors that they will do so in the coming year.

The major advantages of systems from the major companies relate primarily to the company's background. Each of these companies is very large with extensive sales and maintenance offices supported around the country. In addition, the offerings by these companies are usually designed to fit into their existing computer product line, so there is heavy emphasis on support of existing software products and tools. And networking capabilities, at least to the vendor mainframe equipment, is almost always supported in hardware and software.

The disadvantages of products from these vendors also relate generally to the size of the company. The larger companies are typically slower to respond

to recent developments in both hardware and software, and so their products are much less likely to be "the leading edge of technology". Also, due to their commitment to existing software systems, these companies are less prepared to offer radically new operating system or user interface support. Finally, the experience within these companies is oriented toward computer mainframe environments and are often not experienced in the special demands and possibilities provided by personal computing resources.

3.2 "AI" Workstations

A number of companies have produced special purpose computing systems designed especially for developing "AI" (artificial intelligence) applications. These companies include XEROX, Symbolics, LMI (Lisp Machines Incorporated), and Texas Instruments. These AI products preceeded the majority of the "personal workstations" currently on the market.

The products from these vendors exhibit greater maturity and integration of hardware and software than offerings from other vendors. These companies, especially XEROX, have really pioneered the field. They have introduced a new approach to computing that is not constrained by previous generations of computers. The "programming environment" (comprising the user interface, programming support tools, such as editors, debuggers, etc.) is extremely well developed. In addition, these products support software particularly oriented towards the development of "intelligent systems", which is a long term goal of the COEDS program.

Generally these systems are especially designed to support the programming language LISP, which is most commonly used in artificial intelligence applications. Frequently, there is no support for any other programming languages, which means that existing software, written in traditional programming languages, cannot be run on these systems. Finally, these systems are typically more expensive than the budget proposed for the COEDS design station, however recent announcements show that the price may decrease in the future.

3.3 Workstations from Established Companies

A few other companies have been producing more general purpose personal workstations for a few years. These companies include SUN, Apollo and Silicon Graphics. Their offerings have typically been oriented toward the CAD/CAM market.

Since these companies entered the market precisely to develop personal workstations, they have a lot of experience in this new mode of computing. They are new companies with relatively low overhead, and do not have to contend with the difficulties of compatibility with previous products. Therefore, their systems typically display excellent integration in the area of personal computing.

However, since these companies are relatively new, they are severely strained to produce well-tested hardware and a full complement of high quality software products to utilize the hardware capabilities. In addition, these companies frequently use proprietary designs for various critical components of the system such as backplane, network interfaces, etc. These designs provide greater hardware performance, but severely restrict the availability of third party products. Both software and hardware maintenance is more limited from these companies than from established computer vendors.

3.4 Workstations from Emerging Companies

A large number of companies have recently been established to produce engineering workstations. Typically these systems are built around one of the new 32-bit microprocessor chips (such as the the Motorola 68000 or National 32032) and the UNIX operating system.

The offerings from these startup companies typically are pushing the limits of current technology. They attempt to offer the most resolution, fastest graphics, or most CPU power. In addition, the price/performance ratio of the hardware in these systems is very attractive. The companies are typically small with little overhead, and offer the most attractive price possible to help them break into the market.

The disadvantages of all of these companies revolves around the ultimate viability of the company. The computer market is extremely competitive and even some large established companies have lost large amounts of money with new product introductions. In an attempt to reach the market early, these systems are often not well integrated. Portions of the hardware may not be available or not be tested in a computing environment. Relatively little software support is provided directly by the vendor. Typically users rely on in-house development and/or software compatible with the UNIX operating system. Maintenance on products from new companies is frequently a major problem.

Although these companies offer interesting hardware capabilities, it does not seem wise to base a long term program such as COEDS on a company that is not already well established.

3.5 Microcomputers

Microcomputers such as IBM compatibles are offering ever faster CPUs. The total system, however, remains relatively smaller than a work station. The peripherals supported and the degree of expansion remains limited.

Microcomputers are attractive primarily because of their wide availability and low entry cost.

To construct a total system to meet the needs of the COEDS project, however, the total cost will be significantly more expensive than the cost of a basic microcomputer. In addition, the complete system will require several different vendor products for such things as high-resolution graphics boards, large disks, etc. This typically leads to problems of integration, and especially maintaining hardware maintenance. Software products for microcomputers are not generally of the quality expected on mainframe computing environments. And there are often problems of integrating the software with the combined hardware system. The packaging of these small systems, particularly in terms of power supplies and backplane severely limit the expansion capabilities of such a system.

4.0 RECOMMENDATION FOR COEDS ENGINEERING DESIGN STATION

We recommend the Digital Equipment Corporation (DEC) VAX-Station II (VS II) for COEDS. It meets the requirements specified in this report, and falls within the equipment purchase allocation proposed for COEDS. The specific items of hardware and software we recommend for purchase are shown below with estimated prices.

Item	Description	Price
1.	VS II Packaged System with:	$26,972.00
1.1	RD53: 71 MByte Hard Disk	
1.2	TK50: 95 MByte Streaming Tape	
1.3	High Resolution Monitor	
1.4	Keyboard	
1.5	Mouse	
1.6	1 MByte Main Memory	
1.7	Micro VMS Operating System	
1.8	DEQNA: Ethernet (LAN) Interface	
2.	DECNET End Node Software	455.00
3.	VAX FORTRAN Software License	941.00
4.	VAX LISP Software License	546.00

Note: These are the DEC prices to the University of Kansas. An additional discount of 10% may be available if we receive permission from the U.S. Navy to purchase, using the GSA price schedule.

The VS II is a completely integrated system including the required hardware components, software and a network interface in the basic price. The VS II is the most recent DEC introduction in its VAX computer line, and is object-code compatible with earlier VAX computers such as the VAX-780 and VAX-750. These computers have been used very extensively in the engineering and scientific areas, and there is a vast amount of software designed to run on VAX computers. Due to the popularity of the VAX computers, there are numerous third party sources for both hardware and software upgrades for these computers. These are all important features to consider in evaluating the total price of the system.

Since the VS II is object-code compatible with other VAX computers, any programs that are currently running on VAX computers can be used directly on

the VS II, with no changes at all. Since the VS II has compilers for all the major computer languages, programs written on other computers can be converted for use on the VS II. In addition to its own network protocol, DECNET, the VS II supports through software other protocols such as token rings and the IBM SNA.

The hardware configuration of the VS II meets or exceeds all of the requirements specified in an earlier section of this report. The CPU is a DEC proprietary chip set that implements their VAX computer instruction set. It contains both 32-bit address and data paths throughout the design. The VS II display is currently only available in monochrome. There are, however, plans to announce a color version in the coming year. In addition, third party vendors already offer color monitors that are compatible with the VS II.

The VS II runs the DEC VMS operating system that is used on all other VAX computers. This operating system is widely used in the engineering field for software development. DEC supports a full complement of high quality language compilers including FORTRAN, BASIC, Pascal, and COMMON Lisp. DEC's software products are well integrated, so that a program written for any DEC supported language can call a subroutine written in another language. For the VS II, there is a standard library which permits application programs to call the system routines used by the operating system to manage the multiple window environment supported on the high resolution display.

As mentioned earlier, an Ethernet interface is included in the basic price of the VS II. All VAX computers can support the DEC network protocol, DECNET, which supports even such high level capabilities as remote login from another computer. In addition, DEC provides numerous software packages to interface their equipment to other network protocols.

Finally, the size and previous success of DEC in the computer market has been a significant reason for choosing the VS II. DEC is currently the second largest computer manufacturer with an extensive sales and service network world-wide. The VAX computer line (of which the VS II is the newest member), has been supported for the past eight years by DEC. Each new introduction has been object-code compatible with all previous models, meaning that all existing applications can run on the new system with NO changes. The microVAX II

(the VS II CPU) appears to be the new "flagship" in the DEC line, so one can expect continued support of this line with regular new introductions that increase the price performance ratio. Although only introduced six months ago, this line of computers has been extremely well received in the market-place, assuring a wide base of third party software and hardware products.

We believe that the VS II is a wise long-term decision for the COEDS program. Included with this report is a DEC summary of the VS II product.

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